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POTENTIAL PRODUCTION OF SOYBEANS IN NORTH CENTRAL INDIA

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PREFACE

This report relates to the potential production of soybeans, a new crop for the commercial market, in two states of north central India. It is one of two studies made to determine whether it is feasible to establish a modern processing plant with a daily capacity to convert 200 to 500 tons of soybeans into oil and meal of a quality suitable for processing into protein-rich foods for human consumption. The other study relates to the design, equipment needs, building costs, and other requirements of the processing plant, including foreign exchange requirements. This study explores the potential for producing enough soybeans to supply the needs of such a plant.

Soybean production scientists who have carried on research since the middle 1960s are convinced that the soybean has great potential in India. These scientists believe that the production of soybeans would increase farm income and provide a cheap, additional supply of high-quality protein suitable for human consumption, as well as badly needed oil. Accordingly, in late 1969, they requested the U.S. Agency for International Development (USAID) to study the production potentials and the feasibility of establishing processing plant operations in the states of Uttar Pradesh and Madhya Pradesh.

In carrying out the first part of that assignment, the authors necessarily had to work with limited information because the soybean is still an unknown crop to all but a few of India's farmers. A basic analysis of the economics of soybean production in India was available in Misra's unpublished Ph.D. thesis (9) and a related study, recently published (3). On the basis of scanty information on soybean yields, prices, and costs, Misra, through the use of linear programming techniques, analyzed the potential for soybeans on samples of small, medium, and large farms in Madhya Pradesh. That thesis provided valuable insights that were useful in planning and developing this research.

Considerable additional information about production costs and returns from soybeans and competing crops in Madhya Pradesh have become available from findings of extensive field studies in Madhya Pradesh (5). Those findings were taken into account in developing the estimates reported in this publication.

While some background information is available, the remaining gaps in knowledge about the factors likely to influence soybean production in India preclude offering this report as more than a rough approximation of soybean production potentials. We have dealt with the gaps that are known to us by using what we consider to be conservative assumptions.

Although our estimates are intended to be realistic, a potential processor who is selecting a location for processing facilities should carefully check potential supplies in any area that is being considered before making a final decision upon a plant location. That is essential in order to take into account such factors as local climatic and soil conditions, socioeconomic considerations,

likely competition for supplies of soybeans in the area, and other factors we were unable to consider in detail that may influence quantities of soybeans available for the plant.

In addition to being valuable as an appraisal of the potential for soybeans in north central India, this material also illustrates a type of approach to such a study. The methodology employed here can be useful in making initial estimates of likely areas and extent of production of soybeans (or of any other new crop) in any underdeveloped country in the world.

SUMMARY

Recent trials with improved varieties of soybeans imported from the United States indicate that, when grown using production practices adapted to conditions in India, soybeans have about the same yield potential in north central India as in the United States. For this reason, soybeans appear to have a large potential in India for increasing farm incomes and reducing India's huge deficits of high-quality protein foods and edible oils. The realization of these potentials will require the development of new and expensive processing facilities for producing soybean food products of high quality, thereby providing India's farmers with good market outlets for soybeans.

This study was undertaken to estimate potential production of soybeans and to delineate possible supply areas in Uttar Pradesh and Madhya Pradesh that are capable of producing enough soybeans for processing plants with daily capacity of 200 to 500 tons. The analysis was based upon the assumption that, beyond allocating the resources needed to produce enough food and feed for subsistence needs, India's farmers will allocate their land and other resources among alternative crops on the basis of their comparative advantages as sources of money income.

At the yield levels obtained by farmers using recommended packages of practices, the soybean as a kharif crop produces returns over cash expenses for seed, fertilizer, and pesticides that range from approximately one-sixth larger to more than double those from six competing kharif-season crops traditionally grown in north central India. As short-season crops, the new varieties of soybeans also provide a much more remunerative opportunity than has previously existed to crop during the kharif season land which otherwise would be kept fallow in preparation for wheat or other rabi crops. New soybean varieties also provide increased incentive to use land now held under current fallow.

We developed estimates of soybean production potentials in Madhya Pradesh and Uttar Pradesh by districts. In making those estimates, we assumed that in five years from the time active promotion of soybeans started in an area farmers would grow the crop on 10 percent of the area now in jowar, kharif pulses, small millets, and kharif fallow, and on 5 percent of the area under maize, bajra, low-yielding upland rice, cotton (as a mixed crop on 10 percent of the cotton area), and current fallow. We assumed that soybean yields would average 12.5 quintals per hectare. Because the improved type of soybean is a new crop to India, well-planned and effectively implemented promotional and educational programs must be provided to realize the indicated production potential within five years. These programs must assure cultivators not only of markets at remunerative prices, but also of needed seed, inoculum, fertilizer, technical assistance, and credit.

A plant capable of processing soybeans into oil and soy protein products of high quality, suitable for human consumption, involves a large capital investment. To keep unit costs low, such a plant needs to be operated as nearly full time as is practicable. On the basis of 330 operating days per year, which is considered a realistic goal by industry, annual supplies of soybeans needed by plants of 200 to 500 tons daily capacity would range from 66,000 to 165,000 tons.

As estimated, using the assumptions previously described, potential soybean production in several areas in southwestern and central Uttar Pradesh and western

Madhya Pradesh would be sufficient to supply a carefully located plant of 500 tons per day capacity from a circular supply area with a radius of approximately 100 kilometers (62 miles). Within a radius of 150 kilometers (93 miles), estimated supplies in those areas would be roughly twice those needed for a 500-ton plant. Most other parts of Uttar Pradesh and all of the other sections of western Madhya Pradesh have the potential to supply a plant of 200 tons daily capacity within distances over which it is feasible to assemble soybeans by truck.

To the extent that the assumptions used prove to be sound, these estimates indicate levels of production that may be attained in those areas where effective promotional programs are carried on for periods of five or more years. We should not expect promotion on this scale to be conducted over large areas in the early years of the industry. Consequently, in the beginning, production is likely to develop on a substantial scale only in relatively small areas. Accordingly, for some time only a small proportion of these states' aggregate potential production is likely to be realized.

However, if the assumptions used are sound, potential production will be sufficient to provide some choice in plant location. That would permit selecting a location that has a conveniently available supply of soybeans and meets other important needs. Among the other desired characteristics of a plant location are:

1. Relatively low costs of marketing the plant's products.

2. Good rail and highway facilities.

3. Adequate supplies of needed electricity, water, and labor at reasonable cost.

4. A favorable social and political climate for industry.

In areas of high density of potential supplies, another consideration should be the possibility that the location will serve as a center for further expansion of soybean processing operations, capable in time of serving a much larger supply area than the one from which supplies initially are drawn.

The district-by-district estimates of potential soybean production presented in this publication are not based upon the detailed research at local levels that is essential in deciding upon specific sites for processing facilities. Although these estimates delineate what appear to be promising areas of soybean production, a prospective processor should supplement them with careful study of specific conditions in each area being considered as a possible location for soybean processing facilities. His investigation should involve detailed analysis of the suitability of local climatic and soil conditions for soybeans, the prospective place for soybeans in prevailing cropping systems, local farmers' interest in trying a new crop, possible competition for supplies of soybeans, other factors likely to affect the quantities of soybeans available to the plant, and the suitability of the site in other respects.

POTENTIAL PRODUCTION OF SOYBEANS IN NORTH CENTRAL INDIA

SOYBEAN PRODUCTION AND RESEARCH IN INDIA

Early Production and Research Experience

The soybean originated in Asia. Quite likely it was grown in India long before it was introduced into the United States in the early 1800s.

The early Indian soybean was a small black-seeded variety still grown in some localities, as in the hills of northwestern Uttar Pradesh. It is a long-season vegetative type, lower in yield and in oil content than the varieties recently introduced from the United States.

Limited experimental work was begun with soybeans as far back as 1822. As a result of research carried on from 1917 to the 1950s, important improvements were made in yields and oil content. However, the results were generally so discouraging that the agricultural research committee of Madhya Pradesh gave up soybean research in 1953 because of inability to develop a variety that would yield well, fit into the rotation with wheat, and survive drought on nonirrigated land (12).

Recent Soybean Variety Trials

Prospects for soybeans in India took a new turn in the middle 1960s as a result of tests of U.S. varieties initiated in Uttar Pradesh and Madhya Pradesh in north central India (Appendix, Figures 1-3) under the University of Illinois-USAID (U.S. Agency for International Development) program for university development. These trials were begun in 1963-64 by Ed Bay, then an agricultural extension advisor at the Uttar Pradesh Agricultural University. In 1965, more extensive trials of imported varieties were begun by Earl Leng, a University of Illinois agronomist assigned to Uttar Pradesh Agricultural University (later renamed the G. B. Pant University of Agriculture and Technology) at Pantnagar, and by W. D. Buddemeier, an agricultural economist assigned to Jawaharlal Nehru Krishi Vishwa Vidyalaya at Jabalpur, Madhya Pradesh. The results in 1965 were not spectacular. In 1966, however, yields of the Bragg variety on research plots averaged 55 bushels per acre (about 37 quintals per hectare) and yields of other varieties tried ranged from 45 to more than 50 bushels per acre, or from 30 to 34 quintals per hectare (12).

The soybean varieties used in these trials were varieties that had been developed for production in southeastern United States. They were early-maturing types (105 to 120 days), which could be harvested in time to be followed by wheat or other rabi crops (7). Some of these varieties appear suitable for production in north central India. Moreover, all of them are additions to India's stock of genetic materials. As such they are available for use in developing, through adaptive research, varieties that may be even better suited to Indian conditions.

Current Soybean Production Research

In 1966, on the basis of the early successes with imported varieties, University of Illinois scientists assigned to USAID university development programs in India (with the backing and support of their Indian colleagues) submitted

to USAID, for its consideration and transmittal to the Government of India, a proposal for a comprehensive soybean research program embracing work in the fields of plant genetics, agronomy, pathology, entomology, and agricultural economics. In response to this proposal, a coordinated soybean research project was initiated in 1966 as part of the Illinois-USAID university development program. In addition, early in 1967 the Government of India authorized and provided funding for an all-India coordinated soybean improvement program with staff and facilities at several agricultural research locations throughout India--a program of which the studies at Pantnagar and Jabalpur are integral parts (7).

This rapid response to requests for the strengthening of India's soybean research programs reflected an awareness of the potential that soybeans have for serving each of several of the nation's important needs. These needs include (1) raising the output and productivity of Indian agriculture, (2) providing a relatively cheap and abundant source of protein-rich foods badly needed to improve the quality of nutrition, and thereby the health and work efficiency, of large numbers of people, and (3) increasing domestic production of edible oil to reduce large deficits and imports.

NEED FOR SOYBEAN MARKET OUTLETS

Realization of India's soybean production potential will require a complex of changes. The improved varieties of soybeans now being tried are a crop with which very few Indian farmers are familiar. Soybean production will require a reallocation of land, labor, and capital from existing uses--in many cases uses of long historical standing.

Moreover, no matter how successful farmers are in producing soybeans, the reallocation of resources to soybeans will not be profitable to farmers unless remunerative markets are developed for the crop. Until 1970, the principal market for the newly introduced varieties of soybeans was for use as seed. The quantities needed for use only as seed obviously are too limited to provide the basis for large increases in production.

The potential of soybeans as a commercial crop will be evident only when processing facilities become available that will produce soybean products that are adapted to market conditions in India. Although determination of that potential will depend upon extended experience in production and in product development and marketing, it cannot begin until suitable commercial processing facilities are available. The conversion of soybeans into products of commercial value is predominantly a manufacturing process. It is one which, because of economies of scale and technical considerations, commonly requires a large capital investment in plant and equipment as well as highly specialized skills. To operate economically, a soybean processing industry will need a large supply of soybeans within an area from which they can be assembled at comparatively low cost.

PURPOSES AND SCOPE OF THIS STUDY

The objective of this study is to evaluate soybean production potentials in the states of Madhya Pradesh and Uttar Pradesh in order to determine where the potentials are large enough to meet the needs of modern solvent extraction plants

with a daily capacity of 200 to 500 tons of beans. This range in plant size was chosen in consultation with specialists familiar with modern soybean processing operations. It is believed that the objective of minimizing costs of assembly, storage, processing, and marketing of finished products will be achieved in India with plants in this size range.

Under Indian conditions, the supply of soybeans for a plant should be produced within a radius of 100 or, at most, 200 kilometers from the plant (a kilometer is 0.62 mile). This is so because the costs of assembling larger quantities of raw material over longer distances than these may not be compensated by the economies of scale of larger plants (17, pp. 24-26, 139-141). The degree of concentration of soybean production will have a relatively heavy impact on the cost of soybeans at the plant site, and thus on prices that can be paid to farmers. For this reason, we have attempted to gauge soybean production potentials in the two states on a district-by-district basis. With this information it is possible to determine the groupings of contiguous districts with the largest potential production.

ASSUMPTIONS AND METHODS OF ANALYSIS

Factors Involved in Choice of Crops

Most farmers in Madhya Pradesh and Uttar Pradesh give priority to producing crops for household consumption and livestock feed before allocating resources to production for market. Subject to this constraint, the choice of crops to which farmers allocate their resources depends upon their assessment of the comparative advantage, as sources of money income, of cropping systems which include the crops that are being considered. In making this assessment farmers consider limitations in their resources and such other factors as risk and uncertainty. If, over a period of time, Indian agriculture becomes more commercialized, farmers, in their choice of crops, will place more emphasis upon comparative returns and will give less attention to providing food and feed for home use.

For the purposes of this study, it is assumed that soybeans will be grown initially only in the kharif season. This may lend a conservative bias to our estimates of soybean production potentials, because in recent experiments with 19 varieties of soybeans as an irrigated spring-season crop in Uttar Pradesh, yields ranged from 28.8 to 40.9 quintals per hectare (43 to 61 bushels per acre) (8). Yet even with these yields, spring-crop soybeans appear to have no decisive economic advantage over high-yielding varieties of wheat, with which they would compete for the use of irrigated land. Hence, soybeans are unlikely to displace high-yielding varieties of wheat unless price-cost relations become relatively more favorable for soybeans as a result of increased demand for soybeans, or increased supply of wheat relative to demand, or a more rapid rate of technological advance for soybeans than for wheat.

(It is reported that a spring crop of soybeans could be raised without displacing other crops after the final harvest of sugarcane and after potatoes. If this possibility can be realized, it could increase the potential production of soybeans in northern, particularly northwestern, Uttar Pradesh.)

For soybeans to be substituted for other kharif crops, cropping systems that include soybeans must be more profitable than cropping systems that include competing kharif-season crops. If, as frequently is the case, two competing kharif

crops are each followed by the same rabi crop (which commonly is wheat) the choice between them is likely to depend mainly upon their relative profitability as kharif crops. Consequently, this analysis is based primarily upon the comparative returns from soybeans and the kharif-season crops with which they compete. It is true, however, that long-season crops, such as the traditional varieties of jowar, normally are not followed by rabi crops. This fact should be borne in mind in considering possible replacement of those crops by soybeans.

We would expect the extent and rapidity with which soybeans will be substituted for another crop to be influenced by the amount by which returns from soybeans (or the rotation including soybeans) exceed returns from the competing crop (or rotation). If soybeans, or the soybean rotation, is only 10 percent more profitable than the competing crop or rotation, the odds are that initially few farmers would divert land to soybeans, and that the rate of adoption would be slow. If, on the other hand, the difference in returns amounts to 100 percent or more, as it has with high-yielding varieties of wheat, the percentage of farmers initially interested in soybeans and the rate of adoption would be relatively high.

Crops and Land Uses with Which Soybeans Will Compete

Considering both states, rice, maize, jowar, bajra, and minor kharif pulses and millets appear to be the principal kharif crops with which soybeans will compete for land. Because rice is a widely used, well-liked food which, under favorable conditions, yields a high value of output per acre of land, we have assumed that soybeans would be unlikely to displace any except possibly low-yielding upland rice. Soybeans might compete successfully with upland rice if, as we believe, soybeans are more tolerant than rice to frequently recurring moisture deficits. That is, however, a question on which further research is needed. (Groundnuts were excluded from consideration because it was believed that soybeans would not compete successfully with them in areas that are well suited to groundnuts.)

An additional possibility is that of growing soybeans on land that is under current fallow, and on land planted to rabi crops but which lies fallow during the kharif season. Current fallow is defined as land on which a crop was grown in the preceding year and none is grown in either the kharif or rabi season of the current year. The reasons for current fallowing of land in Madhya Pradesh and Uttar Pradesh comprise a subject which the writers of this report cannot discuss with authority.

In both states, large areas of unirrigated land are kept fallow during the kharif season. This practice apparently is followed in the belief that it conserves badly needed moisture for the rabi-season crop and, in areas of heavy soil, because it facilitates seedbed preparation for the rabi crop. Other reasons for the practice may include difficulties in tending to crops of heavy soil during the rainy season, and in the past, lack of profitable kharif-season crops of sufficiently short duration to be followed successfully by rabi crops. Behind these practices is the fact that, in large areas of Madhya Pradesh and Uttar Pradesh where rice is unimportant, many farmers traditionally have depended upon rabi crops as the mainstay for their livelihood.

Because the newer varieties of soybeans are a short-season crop, it appears possible to produce both soybeans and a rabi crop successfully on large areas of land that now lie fallow during the kharif season. However, research is needed into the reasons why farmers have fallowed land in the kharif season and the

benefits thus obtained, into other feasible means of getting those benefits, and into the possibilities of cropping such land now that shorter-season kharif and rabi crops are available.

For the purpose of this report, the net return from soybeans and from each competing crop has been assumed to be the product of its yield times its market value per unit at the farm minus its cost of production. In the computation of costs, we have assumed that land and other overhead costs will be the same for all crops and land uses. We have further assumed that labor needs of soybeans are sufficiently comparable with those for competing crops that differences in labor costs can be ignored for all practical purposes. Hence, in considering costs we have taken account only of costs for seed, fertilizer, and pesticides.

Prices of Soybeans

Except for soybeans, for which markets are not yet fully developed, product prices used in the calculation of relative profits are as reported by cultivators in Madhya Pradesh or in Indian statistical series. In the case of soybeans, we used estimates of the worth of soybeans as a source of oil and meal, minus estimated processing and marketing costs, in accord with data presented in Table 1.

Table 1. Basis for Estimating Prices to Farmers in India for Soybeans Processed for Oil and Meal

Item	Rupees per ton
Groundnut oil prices, Bombay (averages, in rupees, 1967, 3,850; 1968, 3,010; 1969, 4,170; 1970, 4,820; 1971, 4,195)	4,009
Estimated differential between soybean and groundnut oil, (1) and personal correspondence	-250
Estimated return from soy oil	3,759
Groundnut cake prices, Bombay (averages, in rupees, 1967, 525; 1968, 461; 1969, 509; 1970, 549; 1971, 433)	495
Estimated return from soybean meal (495 rupees + 10%)	544
Yields of soybean oil and meal. Oil, 10.6 lb. per 60 lb. bushel = 17.7; meal, 47.6 lb. per bushel = 79.3% (4)	
Returns per ton soybeans from oil and meal Oil, 17.7% X 3,759 = 665 Meal, 79.3% X 544 = 431	1,096
Less: Estimated cost of assembly, processing, marketing (10)	-185[a]
Estimated net price to farmers per ton	911

[a]This estimate allows 20 rupees per ton for transportation from the point of purchase to the mill. At the average truck rate of 0.106 rupee per ton-kilometer reported by von Oppen (17, p. 139), this would cover transportation over 180 kilometers (117 miles).

The potential value of soybeans for use in human food may be somewhat larger than their value when processed into oil and meal, with the meal sold or exported for livestock feed. In India, however, there are some market bases for estimating the worth of soybeans for oil and meal used for livestock feed, whereas markets for their uses in high-value foods are not yet sufficiently developed to provide an adequate basis for such estimates.

The above assumption may lend a conservative bias to our estimates of soybean production potentials. It is our thesis, however, that if adequate supplies will be produced at the prices that can be paid by an efficient processing plant with facilities to produce oil and high-quality meal, this is sufficient to serve the specific purpose of this study--that is, to determine the economic feasibility of building a processing plant, and to appraise potential supplies.

In time, a market for higher-value soybean food products and manufacturing facilities for them may develop. If so, that may lift soybean production potentials to a higher level than we have indicated.

Rate and Extent of Adoption of Soybeans

Even where soybeans have a comparative advantage to achieve production of the volume required to supply the needs of a plant processing 200 to 500 tons per day within an area from which they can be assembled economically will take several years. It also will require, in addition to a dependable market, a well-planned, effectively implemented soybean promotional program.

The estimates of potential soybean production shown in this publication are estimates of the production that would be attained at the end of an effective five-year promotional program. It is assumed that the program would assure producers of a market for soybeans at 90 rupees per quintal at the village level, and would provide them with technical assistance and needed supplies--on credit--of seed, inoculum, fertilizer, and insecticides.

The extent to which farmers adopt soybeans would be determined by many factors. An advance estimate may involve a wide margin of error. The estimates used in this publication are intended to be conservative judgments, but they are not forecasts. If the reader believes other estimates would be more reliable, he should substitute them for ours.

STUDY FINDINGS

Comparative Returns from Soybeans and Competing Crops

Net returns above expenses for seed, fertilizer, and pesticides are estimated for soybeans and for six crops with which soybeans are expected to compete (Table 2). For all these crops except bajra and upland paddy, estimates are based in part upon findings from extensive field studies in Madhya Pradesh in the 1970-72 seasons (5,6). However, yield estimates for all crops except soybeans also reflect reported averages in the two states (2). The yield used for soybeans (12.5 quintals per hectare) is believed to be attainable within five years in areas suited to soybean production in which farmers are trained in techniques of soybean production and use seed and inoculum of good quality, and have access to the credit and fertilizer needed for soybean production.

Table 2. Estimated Net Returns per Hectare, above Expenditures for Seed, Fertilizer, and Insecticides, from Soybeans and Competing Crops[a]

Crop	Amount per Hectare: Expenditures for: Seed	Fertilizer	Pesticides	Total	Gross returns: Yield	Value[b]	Net above direct crop expense
	(rupees)				(quintals)	(rupees)	(rupees)
Soybeans	160[c]	200	25	385	12.5	1,125	740
Maize	40	135	--	175	12.0	810	635
Jowar	15	15	--	30	6.0	510	480
Bajra	15	15	--	30	6.5	590	560
Upland paddy	25	10	--	35	8.0	530	495
Kharif pulses[d]	15	10	--	25	3.8	475	450
Small millets	15	--	--	15	4.0	260	245

[a]Expenditures on and returns from all crops listed, except bajra and upland paddy, are based in part upon findings from extensive field studies (5,6). As more reliable information becomes available it may be substituted for that used in the table.
[b]Includes estimated value of fodder, if appreciable.
[c]Includes cost of inoculum.
[d]Arhar (tur) not included.

Items of information evaluated in making the decision about soybean yields, and sources, were:

Average yield of 30 farmers in Tarai area of Uttar Pradesh in 1968 of 16.2 quintals per hectare (15).

Average yield of 48 farmers in Tarai in 1969 of 18.5 quintals per hectare (16).

Average for eight Tikamgarh, Madhya Pradesh, producers in 1968 of 17.5 quintals per hectare (13).

Average for 14 growers of Bragg variety in 1969 (a bad season) of slightly more than 8 quintals per hectare (14).

Averages for 235 growers in six areas of Madhya Pradesh in 1970, and of 183 growers in five areas in 1971, of 9.2 and 7.7 quintals per hectare, respectively (6). Many of these averages were for poor stands produced by first-time growers with little training in soybean production. Although the majority lacked good inoculum in 1970 and rainfall was excessive in 1971, 41 percent in 1970 and 26 percent in 1971 had yields of 10 or more quintals, averaging approximately 15 quintals per hectare.

Average for four areas in Madhya Pradesh in 1972 (5). In this year of generally inadequate rainfall the average yield was approximately 8.5 quintals per hectare.

Soybean yields in the various districts would be expected to vary from the regional average, depending upon climatic, soil, and other conditions. The possibility of such variation is taken into account in the estimates of potential soybean production by districts (Appendix, Table 1).

Estimated net returns above outlays for seed, fertilizer and pesticides from soybeans yielding 12.5 quintals per hectare are 740 rupees per hectare. This amount is approximately one-sixth more than estimated net returns from maize, one-third more than those from bajra, and one-half or more above those from the other crops in the comparison.

(Costs and returns for competing crops as traditionally grown are used in comparing net returns from those crops with net returns from soybeans. This procedure assumes that most farmers will continue to produce other crops by traditional methods. Strong support for this assumption was obtained in large-scale studies of the comparative advantage of soybeans and competing crops in Madhya Pradesh during 1970-1972 [5,6]. These comparisons are based upon average yields. Sufficient information is not available for a dependable analysis of yield variability. Limited experience suggests that soybeans may tolerate a wider range of moisture supplies than most competing crops.)

In addition, soybeans are a sufficiently short-season crop so that it may be possible to follow them with a rabi crop, while that is seldom feasible with native varieties of jowar. However, because of (a) the importance of most of these other crops as subsistence crops, (b) the possibility that under some conditions some of these crops yield as large returns as soybeans, and (c) farmers' inertia to change, we assume that farmers will allocate only a small part of the area planted to these crops to soybeans in five years from the time active promotion of soybean production is initiated.

On the basis of these data on comparative returns and other considerations that are discussed in later sections, we assume that after five year's active developmental work on soybeans in an area, 10 percent of its land in jowar, kharif pulses other than arhar (tur), and small millets, and 5 percent of that in maize, bajra, and low yielding upland rice would be used in the production of soybeans.

Information is not available concerning the effects upon farmers' net returns of growing soybeans on land not otherwise used for crops, such as current or kharif fallow land, or as a mixed crop between normally spaced rows of cotton. These effects will depend upon the net returns from soybeans and the effects, if any, of soybean production upon cost of production, yields, and net returns from the crop that follows at the usual time (if soybeans are grown on fallow land, or upon the companion crop (if soybeans are interplanted in cotton).

Research is especially needed to evaluate the potential for growing both soybeans and a rabi crop on land that otherwise would be fallow during the kharif season. Lacking research findings in any of these areas, we tentatively estimated that, after five years of active promotion of soybeans in an area, 10 percent of the land in kharif fallow, five percent of that in current fallow, and 5 percent of any land in cotton (equivalent to interplanting on 10 percent of the cotton acreage) would be used for soybeans.

Location and Area of Competing Land Uses

Jowar. Jowar (sorghum) is a crop considered likely to be replaced on a comparatively large scale by soybeans. Presumably the extent of replacement will be affected by both the extent to which jowar is produced for on-the-farm use as food and fodder, and the extent to which it is produced on light soils and in drier areas not best suited to soybeans. Nevertheless, it appears that large acreages of jowar are grown in areas suitable for soybeans simply because, up to now, cultivators, while recognizing that jowar is a low-return long-season crop,

have considered it to be the best available use for extensive areas of land during the kharif season. Low-cash outlays on that crop also may have helped to account for its importance (3).

The area in jowar is extensive in many districts in the western half of Madhya Pradesh and in several districts of south central Uttar Pradesh (Appendix, Figure 4 and Table 1). In a number of these districts the 10 percent of the land in jowar assumed to be potentially available for soybeans in five years amounts to one-third to one-half of the total area assumed to be potentially available for soybeans by that time.

Small millets. Small millets (including ragi) are extensively grown as kharif-season crops in the eastern part of Madhya Pradesh and in northeastern Uttar Pradesh (Appendix, Figure 5). (In Madhya Pradesh, the area reported is the total for ragi plus "other kharif season foodgrains.") Small millets are light-yielding crops of low value with which soybeans should compete successfully. The possibility of displacing large areas of these crops enhances the potential for soybeans in the central and eastern parts of the two states.

Kharif pulses. Moong and urid are the two leading short-season pulses grown in north central India during the kharif period. They are among the crops that farmers in Madhya Pradesh are replacing with soybeans. The area in kharif season pulses (excluding arhar or tur) is not large, but it is appreciable in southwestern Madhya Pradesh and in a few of the eastern districts of that state (Appendix, Figure 6).

Maize. Maize (corn) is believed to be less tolerant than soybeans to either shortage or excess of rainfall, and the maturing crop is more susceptible than soybeans to damage by predators. Consequently, even though yields per hectare of maize have been increasing relative to those of crops such as jowar, small-millets, and kharif pulses, some replacement of maize by soybeans is expected.

Although maize is grown in most districts in both states, production is substantial only in western and central Uttar Pradesh and in a few districts of western Madhya Pradesh (Appendix, Figure 7). Even in those districts, land now used for maize and assumed to be potentially available for soybeans in five years (5 percent of the maize acreage) is only a small percentage of all land assumed to be potentially available for soybeans in five years.

Bajra. Bajra is more prized for food than are small millets, jowar, and maize. For that reason, and because bajra is raised largely in areas of limited rainfall and on light soils, it is considered to be less susceptible to competition from soybeans than such crops as jowar and the small millets. Consequently, only 5 percent of the area in bajra is considered potentially available for soybeans after five years of active promotion of soybeans. This land would be mainly in southwestern Uttar Pradesh and a few districts of western Madhya Pradesh, which are the only places where bajra is grown extensively (Appendix, Figure 8).

Cotton. There is much interest in interplanting soybeans between normally spaced rows of cotton. Accordingly, we assumed that by the end of a five-year period of active promotion, soybeans would be produced as a mixed crop on 10 percent of the area in cotton. This is considered equivalent to exclusive production of soybeans on 5 percent of the land in cotton. The area would be mainly in southwestern Madhya Pradesh (Appendix, Figure 9).

Rice. Only a rough approximation could be made of the area now producing low-yielding upland paddy (rice), of which we assumed 5 percent might be used for soybeans after five years of active promotion. Because the area in low-

yielding paddy was not reported as such, the estimate was based on 5 percent of the area in early paddy in districts where yields were not more than one-half the state average, and 2.5 percent of the area in districts where yields were between one-half and the state average. The five years averaged were 1964-65 through 1968-69. The areas thus estimated as potentially available for soybeans were small. They amounted to 3,000 hectares or more in each of four districts of northeastern Madhya Pradesh and in one district in Uttar Pradesh.

Kharif-fallow land. Large areas of land are fallow during the kharif season, particularly in the western halves of the two states (Appendix, Figure 10). In 10 districts of central and western Madhya Pradesh and 5 districts of southern Uttar Pradesh, kharif-fallow land comprises one-half or more of the net sown area. The 10 percent of the kharif-fallow area estimated to be potentially available for soybeans in five years was more than one-half of the area estimated to be potentially available for soybeans in 55 of the 91 districts of the two states.

Reasons for leaving this land fallow during the kharif season, and some of the questions involved in assuming that 10 percent of this land might be available for soybeans in five years, have been discussed in earlier sections of this report. The availability of a short-season remunerative crop will provide incentive to use some of this land for soybeans. Moreover, as irrigation is expanded to provide additional water for rabi-season crops on tracts now fallow during the kharif season, farmers can be expected to commence growing kharif-season crops on most of those tracts. In many areas, soybeans promise to be the most profitable kharif-season crop of those from which farmers may choose.

Current fallow. Relative to the area in kharif fallow, the area in current fallow is small. There are only a few districts, mostly in eastern Madhya Pradesh and central Uttar Pradesh, where more than 25,000 hectares are involved. Consequently, in most areas the five percent of the current fallow land assumed to be potentially available for soybeans in five years is only a small proportion of all land assumed to be available for soybeans.

Total area. The total area estimated to be potentially available for soybeans (10 percent of the area in jowar, small millets, kharif pulses other than arhar [tur], and kharif fallow, plus 5 percent of the area in maize, bajra, cotton, low-yielding upland rice and current fallow) ranged from 2,000 to 45,000 hectares in the various districts of the two states (Appendix, Table 2).

Potential Production of Soybeans

The potential production of soybeans by districts was computed by multiplying the estimated area potentially available for soybeans by estimated yield per hectare in that district. To allow for regional differences in productivity, the estimated yield of soybeans in each district was determined by multiplying the assumed average yield (1.25 metric tons per hectare) by a yield index based upon the relative average yield of maize, jowar, arhar (tur), wheat, and gram in that district during the three cropping seasons 1964-65, 1967-68, and 1968-69. Almost all of these yield indexes lie between 75 and 125. Accordingly, the per hectare yields used for soybeans in the various districts are mainly between 1.0 to 1.5 tons per hectare.

Estimated total potential soybean production by districts was expressed as production per square kilometer, to facilitate comparisons among districts and estimates of supplies available within prescribed areas (Appendix, Figure 11). These data may be used to appraise the apparent adequacy of supplies of soybeans in different areas to support processing plants of various capacities.

Starting with estimated potential supplies of soybeans per square kilometer (if for more than one district, using the approximate average for two or more districts), one can approximate the total potential supply within an area of specified size by multiplying production per square kilometer by the number of square kilometers in the supply area. Assuming circular supply areas, the procedure is illustrated in Table 3. In making the approximation, one can provide for any margin of safety that he wishes to introduce. For example, if a person believes that he can obtain only one-half of the available supply, he can divide the total estimated potential supply of the soybeans in the area he is considering by two.

Table 3. Total Potential Annual Supplies of Soybeans Within Circular Supply Areas of Various Size at Selected Densities of Supplies

Supply area		Total potential supplies of soybeans at density, in metric tons per square kilometer, of						
Radius	Total area	2	3	4	5	6	7	8
Kilometers	1,000 sq. km.	1,000 metric tons						
50	7.9	16	24	32	40	47	55	63
100	31.4	63	94	126	157	188	220	251
150	70.7	141	212	283	354	424	495	566
200	125.7	251	377	503	628	754	880	1,006

Adequacy to Meet Plant Needs

A plant built especially to process soybean products of the quality needed so that the protein as well as the oil will be used for human consumption involves a large capital investment. To operate efficiently, a plant involving such a large investment must be run at as nearly full capacity as possible. Industry sources indicate that 330 days per year is a realistic goal. On the basis of 330-day operations, the quantity of soybeans needed to operate plants of 200 to 500 tons daily capacity would range from 66,000 to 165,000 tons.[1]

The total supply of soybeans in a circular supply area with an average potential density of 6 metric tons per square kilometer and a radius of 100 kilometers (62 miles) would slightly exceed the quantity needed for a 500-ton-per-day plant (Table 3). With a radius of 150 kilometers (94 miles), at that density the supply would be more than twice the quantity needed by a 500-ton plant. There are several multidistrict areas in Uttar and Madhya Pradesh where the average density of potential supplies, as we have estimated them, approximates or exceeds 6 tons per square kilometer. These areas are in south central and southwestern Uttar Pradesh and in the western half of Madhya Pradesh (Appendix, Figure 11).

[1]In 1970, the cost of a plant with a daily capacity of 500 tons built in India was estimated at 27,250,000 rupees. Working capital for a plant of that size was estimated at 50,750,000 rupees, and fixed costs at 8,400,000 rupees per year, or practically 23,000 rupees per day (365-day basis). Capital investments and fixed costs per ton of capacity were higher than this in smaller plants (11). These estimates did not allow for any substantial equipment for making edible soy protein products. It is important to have an adequate supply of soybeans to operate such a plant at full capacity--not only to hold fixed costs per unit to a reasonable level but also because shutdowns reduce the efficiency of processing operations.

Almost all the rest of Uttar Pradesh except the mountain districts, and all other districts in the western two-thirds of Madhya Pradesh show potential supplies of 3 or more tons of soybeans per square kilometer. At a density of 3 tons per square kilometer, a circular supply area with a radius of 100 kilometers would provide nearly one and one-half times the quantity of soybeans needed by a plant processing 200 tons per day.

These estimates in no sense are meant to suggest that aggregate production of soybeans in Madhya Pradesh and Uttar Pradesh five years after active promotion starts in some area would equal the sum of the estimated potential production in all districts of those states. Instead, these estimates are of production that might be attained in five years within areas in which there is sustained, active promotion. At the end of five years, production at the indicated level should be expected only in those sections where persistent and effective promotion was under way throughout the period. Production at lower levels might develop in other sections, including limited production in areas without effective promotion.

If the assumptions used in estimating potential supplies are sound, many possible locations exist where sustained, active promotion could develop supplies sufficient for processing facilities of 200 or more tons per day capacity. Therefore, in selecting a location, not only should there be the certainty of an adequate supply of soybeans, but the other specifications for a good site also should be met. These other specifications include:

1. A location from which costs of marketing the plant's products are comparatively low. The choice in this respect depends upon the bulk and perishability of the plant's major end products, where they are to be marketed, and other considerations. A plant in a soybean production area, and processing the beans into oil and meal, will ideally be located at a point where one-half or more of the plant's soybeans are moving towards the major markets for oil and meal as they come into the plant.

2. A site on a broad-gauge railway and served by a network of good highways.

3. A location having adequate and dependable supplies of water, electricity, and labor at reasonable cost.

4. An area in which the social and political climate for industry is favorable.

Additional conditions may be considered desirable if attainable. To guard against occasional shortages due to drought, consideration may also be given to the average amount and variability of rainfall in the proposed supply area, and to the extent of existing and potential supplementary irrigation. Finally, if the plant might economically process other oilseeds when the supply of soybeans was short, the availability of other oilseed crops in the area could be a relevant consideration.

The foregoing estimates of potential production in the various districts are not forecasts that production will develop to the indicated extent even with sustained, effective promotion. With the resources available for this study it was not possible to determine and evaluate the effects of regional differences in climatic and soil conditions, in cultivators' attitudes toward change, and in other factors that might influence the rate and extent of a shift to soybean production. Likewise, this study takes no account of possible competition among

buyers for supplies of soybeans in the various regions. Consequently, before deciding upon a plant location, any agency planning to establish soybean processing facilities in India should make a thorough study of climate, soil, and economic and social factors affecting prospects for soybean production, possible competition for supplies of soybeans, and other relevant features of each location that is being considered. Detailed investigation of this kind is necessary to obtain information that is essential to selecting a site for a large investment in soybean processing facilities.

CONCLUSIONS

As estimated in this analysis, soybean production of sufficient density to supply carefully located plants of 200, and in some situations up to 500, tons daily capacity, within areas from which soybeans can feasibly be assembled by truck, appears to be possible in large portions of both Uttar and Madhya Pradesh. Production can be expected to develop on this scale within five years only in areas that have the potential for production at those levels and where there are sustained, effective promotional programs.

In choosing the site for a plant, a prospective soybean processor should supplement the tentative findings made in this study by detailed investigation of soybean production possibilities, likely competition for supplies, and other pertinent factors in the decision as they apply to each prospective site. Only by intensive study of this kind can the prospective processor determine and take into account local climatic and soil conditions and socioeconomic and other factors that should be evaluated in deciding upon a site.

The soybean is a new crop with which most cultivators are unfamiliar. Accordingly, even in areas suited to soybean production, it will take extensive educational and promotional efforts, including assurance of markets, adequate seed and inoculum of good quality, technical assistance, and credit, to realize enough of the production potential within five years for efficient plant operation. It will be important to concentrate such educational and promotional efforts within an area from which the plant's supplies can be assembled economically. Even with effective educational and promotional efforts, the result is likely to be a series of pockets of production, depending upon quality of roads, local rural leadership, and other factors.

The processing plant and firm will occupy a pivotal position in realizing the soybean production potentials in the area where it is located. Its management, buyers, and personnel engaged in assembly and transport of farm supplies will be in direct business contact with many soybean growers upon whose success as producers their own success and that of the firm they represent will heavily depend. Because of such business contacts and the interdependence of interest, the processing firm will be in position to play a leading role in educational and promotional efforts directed to cultivators.

There are various ways in which processors can promote soybean production. One of the most obvious is for the processor to enter into contractual relations, either directly or through agents, with cultivators for their soybeans at announced prices. In such a relationship, the processor can conceivably serve as supplier of seed, inoculum, pesticides, and fertilizers--all on credit--as well as advise the grower on production, harvesting, and storage practices. This arrangement would be analogous to that used in producing broilers and several other specialized agricultural commodities in the United States. Even if other arrangements are used,

the processing firm may find it advantageous to provide effective field agents to furnish technical assistance to farmers.

As noted earlier, many factors other than the location of potential supplies of soybeans should be taken into account in determining plant location. A location that has large potential supplies of soybeans and is well situated in these other respects could serve as a center for later expansion of the soybean processing industry, and that should be given consideration.

The purposes of building a soybean processing plant equipped to produce soybean oil and edible soy protein of high quality include the development, and in a sense the "testing," of production potentials for soybeans, and the provision of a base for further product and market development. Consequently, careful consideration should be given to the research needed to support it.

On the production side, this research might include a five- to six-year program of studies. This could begin with studies of cultivator performance in soybean production and of inputs, production costs, and returns from the crop. An important part of this research should investigate adjustments that may be made in cropping and farming systems of soybean growers, to intensify production and maximize returns.

In marketing, the research might include extensive surveys of acceptance, and factors affecting acceptance, of a wide variety of soybean products. Because numerous food products can be produced from soybeans, market-oriented research also should include the development and adaptation of soybean foods for Indian diets.

If foreign assistance is provided for the building of a plant, consideration might also be given to including any additional financial assistance needed during the first five years of its operation, to provide for educational and promotional programs.

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Appendix, Table 1. Area in Selected Kharif Season Crops and in Kharif Fallow, by Districts, Madhya Pradesh and Uttar Pradesh, India, 1968-69

District	Jowar	Small millets	Kharif pulses	Maize	Bajra	Cotton[a]	Kahrif fallow
			(1,000 hectares)[b]				
Madhya Pradesh							
Raipur	1	63	12	1	--	--	45
Durg	1	196	6	3	--	--	215
Bastar	4	155	52	25	--	--	6
Bilaspur	1	46	23	11	--	--	66
Raigarh	--	50	54	9	--	1	--
Sarguja	4	98	58	35	--	1	--
Jabalpur	21	53	5	7	--	--	213
Balaghat	2	19	3	4	--	--	20
Chhindwara	138	86	22	18	--	8	83
Sagar	43	14	8	4	--	--	323
Narsimhpur	48	19	3	--	1	--	152
Seoni	18	75	6	7	--	--	145
Damoh	20	17	6	2	--	--	143
Mandla	1	143	12	24	--	--	62
Rewa	22	74	5	1	2	--	129
Sidhi	12	107	7	21	--	--	41
Satna	18	52	2	1	--	--	155
Panna	15	23	2	2	--	--	88
Chhatapur	31	52	14	1	--	--	119
Tikamgarh	46	44	7	16	--	--	37
Shahdol	9	116	18	23	--	--	35
Indore	48	--	13	7	1	11	110
Ratlam	67	3	20	28	7	38	48
Ujjain	131	--	21	8	6	61	120
Mandsaur	170	--	61	49	4	14	27
Dewas	99	--	10	7	1	60	77
Dhar	85	--	50	52	15	49	110
Jhabua	34	41	49	78	15	23	17
West Nimar	189	--	98	28	50	128	11
East Nimar	124	--	52	2	5	127	17
Gwalior	23	3	3	--	3	--	152
Bhind	33	20	10	--	36	--	220
Morena	51	6	15	1	83	--	167
Shivpuri	81	11	15	23	6	--	108
Guna	170	1	16	7	--	--	229
Datia	18	2	3	1	2	--	93
Sehore	86	--	6	8	--	13	247
Raisen	21	--	1	2	--	1	300
Vidisha	66	--	8	1	--	--	339
Hoshangabad	38	1	17	2	--	35	259
Betul	82	--	27	2	--	2	82
Raigarh	140	1	7	25	--	41	48
Shajapur	130	--	10	13	1	67	63
All M.P.[c]	2,336	1,692	837	582	240	681	4,830

Appendix, Table 1. Area in Selected Kharif Season Crops and in Kharif Fallow, by Districts, Madhya Pradesh and Uttar Pradesh, India, 1968-69 (continued)

District	Jowar	Small millets	Kharif pulses	Maize	Bajra	Cotton[a]	Kharif fallow
			(1,000 hectares)[b]				
Uttar Pradesh							
Dehradun	--	8	1	13	--	--	3
Saharanpur	--	2	2	37	13	6	62
Muzaffarnagar	1	1	1	21	5	7	61
Meerut	4	1	1	59	22	11	101
Bulandshahr	13	--	1	100	42	12	110
Aligarh	4	--	1	72	110	13	124
Mathura	18	--	1	8	53	12	163
Agra	10	--	1	4	110	2	173
Mainpuri	11	--	--	58	48	--	88
Etah	7	--	--	51	82	1	83
Bareilly	19	4	1	17	15	--	79
Bijnor	--	2	7	8	8	1	75
Budaun	12	--	1	41	82	--	143
Moradabad	16	3	5	29	50	1	142
Shajahanpur	17	3	6	9	27	--	111
Pilibhit	2	2	4	6	5	--	46
Rampur	19	1	--	32	5	--	41
Farukhabad	22	--	--	72	19	--	105
Etawah	11	--	1	30	58	--	95
Kanpur	55	--	2	28	36	1	189
Fatehpur	41	4	4	1	19	--	115
Allahabad	41	17	1	1	55	--	176
Jhansi	120	20	9	17	--	--	245
Jalaun	36	--	--	--	22	--	267
Hamirpur	91	8	4	--	4	--	336
Banda	80	10	--	--	20	--	251
Varanasi	6	11	3	18	16	--	75
Mirzapur	9	48	4	16	13	--	98
Jaunpur	6	7	3	60	9	--	78
Ghazipur	7	14	1	7	15	--	88
Ballia	3	18	--	24	5	--	76
Gorakhpur	--	43	--	11	--	--	122
Deoria	1	58	--	26	2	--	80
Busti	--	54	1	20	--	--	137
Azamgarh	--	24	--	20	1	--	116
Nainital	--	29	1	14	3	--	36
Lucknow	11	5	4	9	9	--	47
Unnao	22	2	3	33	12	--	93
Rai Bareilly	28	7	12	1	10	--	78
Sitapur	6	47	16	46	8	--	128
Hardoi	26	2	9	43	9	--	141
Kheri	6	20	8	61	5	--	99

Appendix, Table 1. Area in Selected Kharif Season Crops and in Kharif Fallow, by Districts, Madhya Pradesh and Uttar Pradesh, India, 1968-69 (continued)

District	Jowar	Small millets	Kharif pulses	Maize	Bajra	Cotton[a]	Kharif fallow
			(1,000 hectares)[b]				
Faizabad	6	18	2	10	--	--	81
Gonda	1	38	4	105	1	--	84
Bahraich	1	21	3	156	1	--	90
Sultanpur	15	15	6	6	2	--	83
Pratapgarh	10	13	7	3	21	--	69
Barabanki	8	21	14	14	5	--	77
All U.P.[c]	826	600	157	1,416	1,056	65	5,360

[a]Data for Uttar Pradesh are for 1967-68.
[b]Dash indicates 0-499 hectares.
[c]Total for districts may not add to state totals because of rounding.

Appendix, Table 2. Estimated Area Potentially Available for Soybeans and Production of Soybeans after Five Years of Sustained Active Promotion, by Districts, Madhya Pradesh and Uttar Pradesh, India

State and district	10 percent of land in Jowar, small millets, kharif pulses[a]	Kharif fallow	5 percent of land in maize, bajra, cotton, upland paddy, current fallow	Area potentially available for soybeans	Potential soybean production: Per hectare	Potential soybean production: Total for district	Potential soybean production: Per square kilometer
	(1,000 hectares)				(tons)	(1,000 tons)	(tons)
Madhya Pradesh							
Raipur	8	4	2	14	1.1	15	1
Durg	20	22	2	44	1.2	53	3
Bastar	21	1	3	25	1.3	32	1
Bilaspur	7	7	3	17	1.3	22	1
Raigarh	10	--	2	12	1.5	18	1
Sarguja	16	--	11	27	1.3	35	2
Jabalpur	8	21	5	34	1.4	48	5
Balaghat	2	2	--	4	1.2	5	1
Chhindwara	25	8	2	35	1.2	42	4
Sagar	6	32	--	38	1.4	53	5
Narsimhpur	7	15	--	22	1.6	35	7
Seoni	10	14	1	25	1.2	30	3
Damoh	4	14	1	19	1.4	27	4
Mandla	16	6	6	28	1.5	42	3
Rewa	10	13	5	28	1.0	28	4
Sidhi	21	4	5	30	1.1	33	3
Satna	7	16	5	28	1.1	31	4
Panna	4	9	3	16	1.2	19	3
Chhatarpur	10	12	2	24	1.3	31	4
Tikamgarh	10	4	1	15	1.4	21	4
Shahdol	14	4	12	30	1.0	30	2
Indore	6	11	1	18	1.1	20	6
Ratlam	8	5	4	17	1.1	19	4
Ujjain	15	12	4	31	1.2	37	6
Mandsaur	23	3	3	29	1.2	35	4
Dewas	11	8	3	22	1.2	26	4
Dhar	14	11	6	31	1.0	31	4
Jhabua	12	2	8	22	1.1	24	4
West Nimar	30	1	11	42	1.2	50	4
East Nimar	19	2	7	28	1.4	39	4
Gwalior	4	15	--	19	1.6	30	6
Bhind	3	22	2	27	1.5	40	9
Morena	7	17	5	29	1.5	44	4
Shivpuri	11	11	2	24	1.2	29	3
Guna	19	23	1	43	1.1	47	4
Datia	2	9	--	11	1.2	13	6
Sehore	9	25	1	35	1.2	42	4

Appendix, Table 2. Estimated Area Potentially Available for Soybeans and Production of Soybeans after Five Years of Sustained Active Promotion, by Districts, Madhya Pradesh and Uttar Pradesh, India (continued)

State and district	10 percent of land in: Jowar, small millets, kharif pulses[a]	10 percent of land in: Kharif fallow	5 percent of land in maize, bajra, cotton, upland paddy, current fallow	Area potentially available for soybeans	Potential soybean production: Per hectare	Potential soybean production: Total for district	Potential soybean production: Per square kilometer
	(1,000 hectares)				(tons)	(1,000 tons)	(tons)
Raisen	2	20	--	32	1.3	42	5
Vidisha	7	34	--	41	1.2	49	7
Hoshangabad	8	26	2	36	1.4	50	5
Betul	18	8	2	28	1.0	28	3
Rajgarh	15	5	3	23	1.1	25	4
Shajapur	14	6	4	24	1.3	31	5
State total	493	494	140	1,127	1.2	1,401	3
Uttar Pradesh							
Dehradun	1	--	1	2	1.0	2	1
Saharanpur	--	6	3	9	.9	8	1
Muzaffarnagar	--	6	3	9	1.2	11	3
Meerut	1	10	6	17	1.1	19	3
Bulandshahr	1	11	9	21	1.3	27	5
Aligarh	--	12	11	23	1.3	30	6
Mathura	2	16	5	23	1.2	28	7
Agra	1	17	7	25	1.2	30	6
Mainpuri	1	9	6	16	1.4	22	5
Etah	1	8	8	17	1.4	24	5
Bareilly	2	8	3	13	1.2	16	4
Bijnor	1	8	2	11	1.2	13	3
Badaun	1	14	8	23	1.2	28	5
Moradabad	2	14	7	23	1.2	28	5
Shajahanpur	3	11	4	18	1.1	20	4
Pilibhit	1	5	4	10	1.2	12	3
Rampur	2	4	2	8	1.3	10	4
Farukhabad	2	10	6	18	1.5	27	6
Etawah	1	10	5	16	1.4	22	5
Kanpur	6	19	4	29	1.4	41	7
Fatehpur	5	12	2	19	1.4	27	6
Allahabad	6	18	7	31	1.4	43	6
Jhansi	15	24	4	43	1.0	43	4
Jalaun	4	27	2	33	1.1	36	8
Hamirpur	10	34	1	45	1.0	45	6
Banda	9	25	4	38	1.2	46	6
Varanasi	2	8	4	14	1.3	18	3

Appendix, Table 2. Estimated Area Potentially Available for Soybeans and Production of Soybeans after Five Years of Sustained Active Promotion, by Districts, Madhya Pradesh and Uttar Pradesh, India (continued)

State and district	10 percent of land in: Jowar, small millets, Kharif pulses[a]	10 percent of land in: Kharif fallow	5 percent of land in maize, bajra, cotton, upland paddy, current fallow	Area potentially available for soybeans	Potential soybean production: Per hectare	Potential soybean production: Total for district	Potential soybean production: Per square kilometer
	(1,000 hectares)				(tons)	(1,000 tons)	(tons)
Mirzapur	6	10	2	18	1.2	22	2
Jaunpur	2	8	4	14	1.3	18	4
Ghazipur	2	9	2	13	1.2	16	5
Ballia	2	8	2	12	1.2	14	4
Gorakhpur	4	12	1	17	1.0	17	2
Deoria	6	8	2	16	1.0	16	3
Basti	6	14	2	22	1.0	22	3
Azamgarh	2	12	4	18	1.0	18	3
Nainital	3	4	1	8	1.2	10	2
Lucknow	2	5	1	8	1.4	11	4
Unnao	3	9	3	15	1.1	16	3
Rai Bareilly	5	8	2	15	1.3	20	4
Sitapur	7	13	7	27	1.2	32	6
Hardoi	4	14	6	24	1.4	34	6
Kheri	3	10	7	20	1.2	24	3
Faizabad	3	8	--	11	1.2	13	3
Gonda	4	8	9	21	1.1	23	3
Bahraich	2	9	11	22	1.3	29	4
Sultanpur	4	8	3	15	1.2	18	4
Pratapgarh	3	7	2	12	1.2	14	4
Barabanki	4	8	2	14	1.4	20	4
State total	157	538	201	896	1.2	1,083	4

[a]Kharif pulses other than arhar (tur).

Figure 1: Map of India showing Uttar Pradesh and Madhya Pradesh

Figure 2: State of Uttar Pradesh, India, by Districts

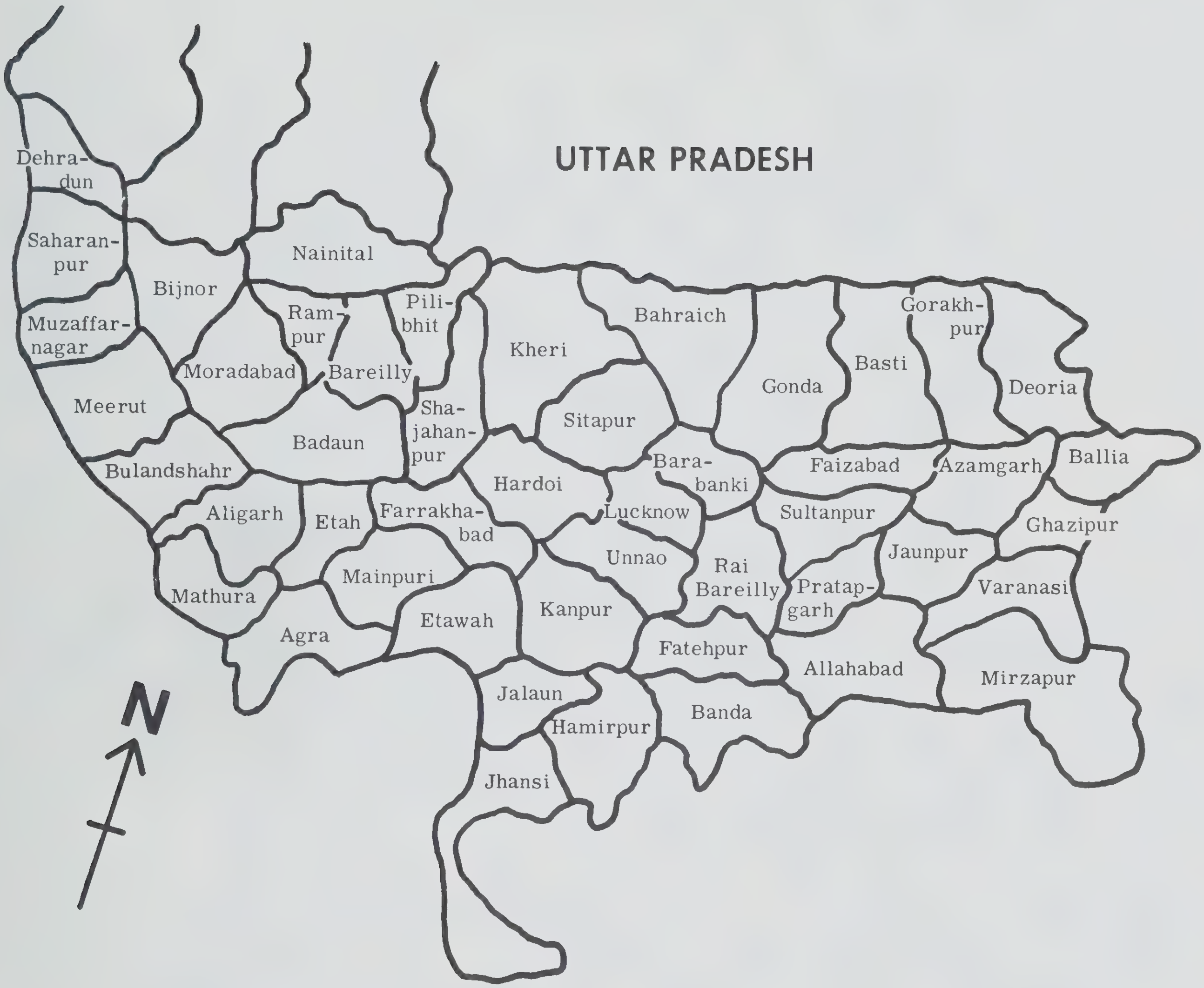

Figure 3: State of Madhya Pradesh, India, by Districts

Figure 4: Area in Jowar (1,000 hectares) 1968-69

Figure 5. Area in Small Millets (1,000 hectares) 1968-69

Figure 6. Area in Kharif Pulses other than Arhar (Tur) (1,000 hectares) 1968-69.

Figure 7. Area in Maize (1,000 hectares) 1968-69.

Figure 8. Area in Bajra (1,000 hectares) 1968-69.

Figure 9. Area in Cotton (1,000 hectares) 1968-69 (Madhya Pradesh) and 1967-68 (Uttar Pradesh).

Figure 10. Land Fallow in Kharif Season (1,000 Hectares) 1968-69.

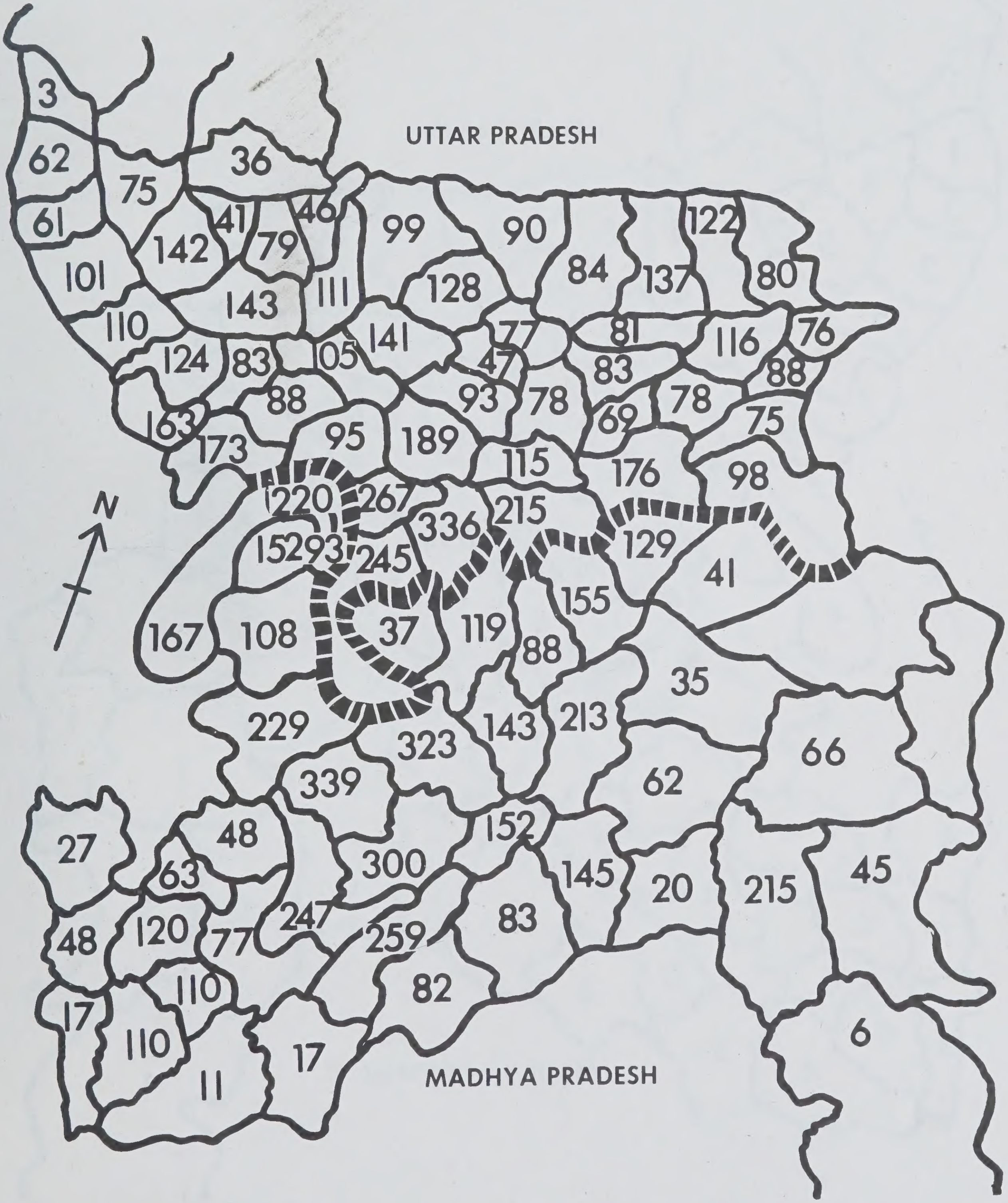

Figure 11. Estimated Potential Production of Soybeans after Five Years of Active Promotion, (metric tons per square kilometer).